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(71) Applicants
Wieland-Werke A.G.,
Postfach 4240,
D-7900,
Ulm,
West Germany.
(72) Inventors
Hans Sick,
Karl-Heinz Knirsch,
Hubert Magg.
(74) Agents
Langner Parry,
52-54 High Holborn,
London WV1C 6RR.

(54) **Process and apparatus for the manufacture of a heat-insulated metal pipe**

(57) A metal pipe (2) is heat insulated by a surrounding seamless extruded PVC foam jacket (3) having internal webs (4) at which it is supported on and bonded to the pipe (2). The pipe (2) is heated prior to passage through an extrusion die (9) to a temperature which is sufficiently high to provide adequate bond between the pipe (2) and the PVC jacket (3) to counteract the tendency of the PVC to lift by expansion from the pipe after leaving the extrusion die but which is not so high that adhesion is lowered beyond the expansion force of the foaming jacket due to a lowering of the viscosity of the melt bond. The plasticised PVC is heated in the extruder and mixed with a foaming gas. The plasticised PVC melt is applied to the pipe whilst in the extrusion die and in order to assist in adhesion between the PVC and the pipe they are both moved with the same velocity in the bonding zone. The webs (4) are shaped by pins (13) which extend downstream from the extrusion die mandrel to a location (15).

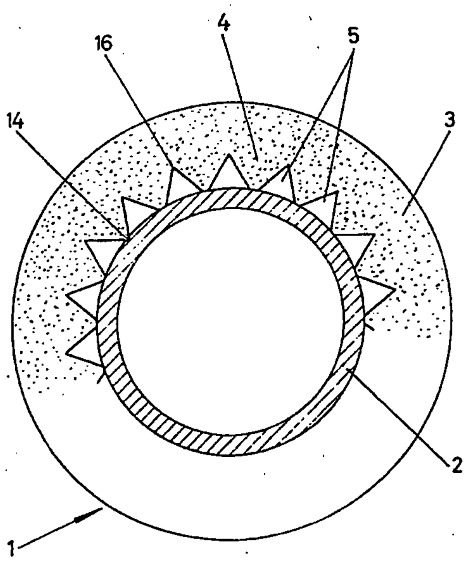

Fig.1

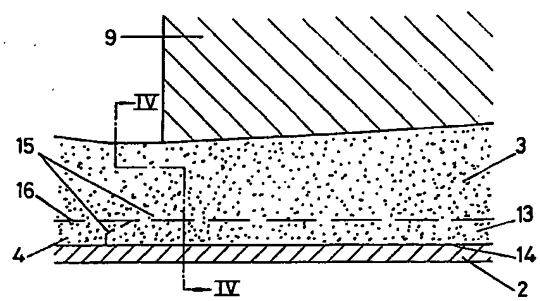

Fig.3

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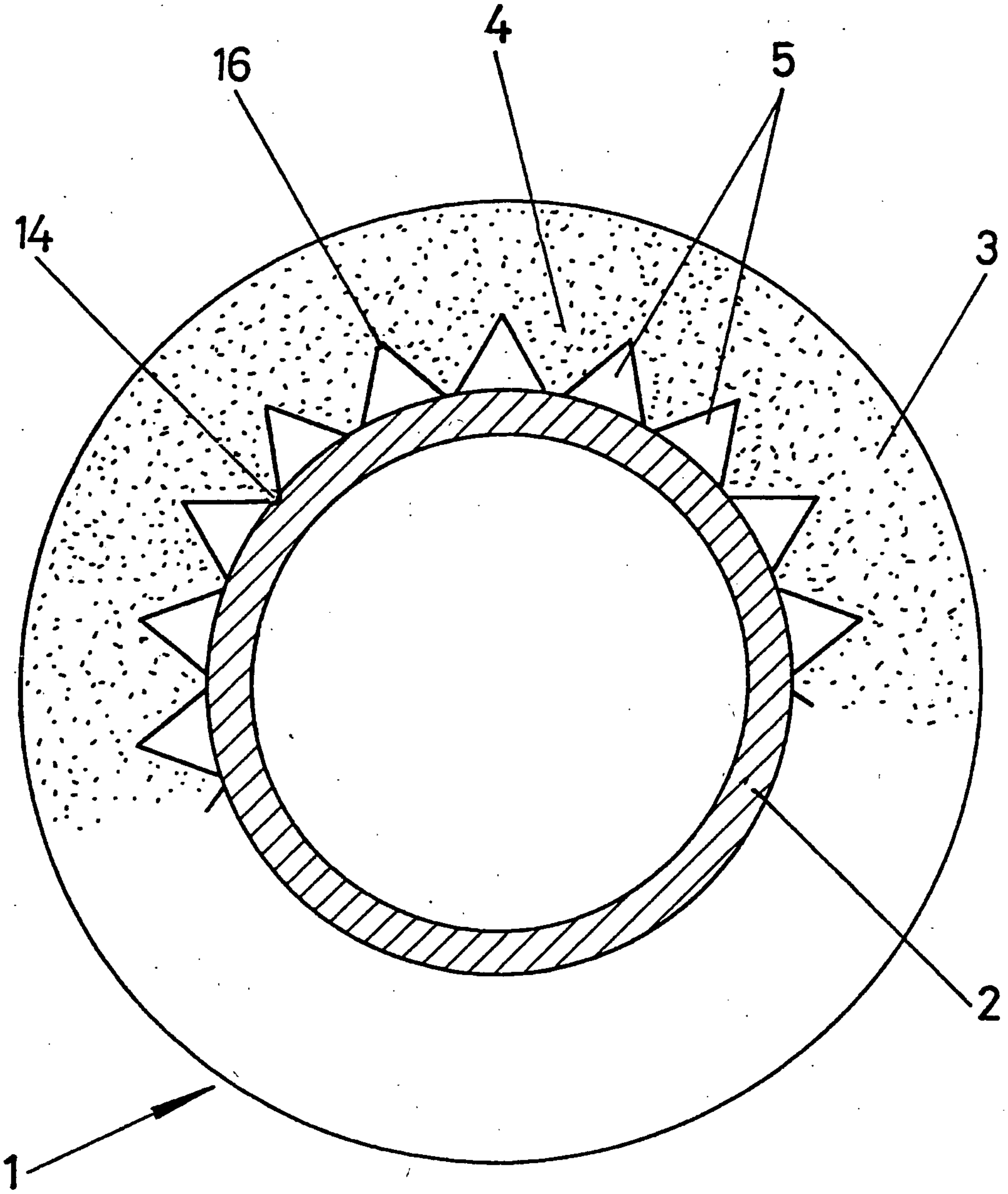

Fig.1

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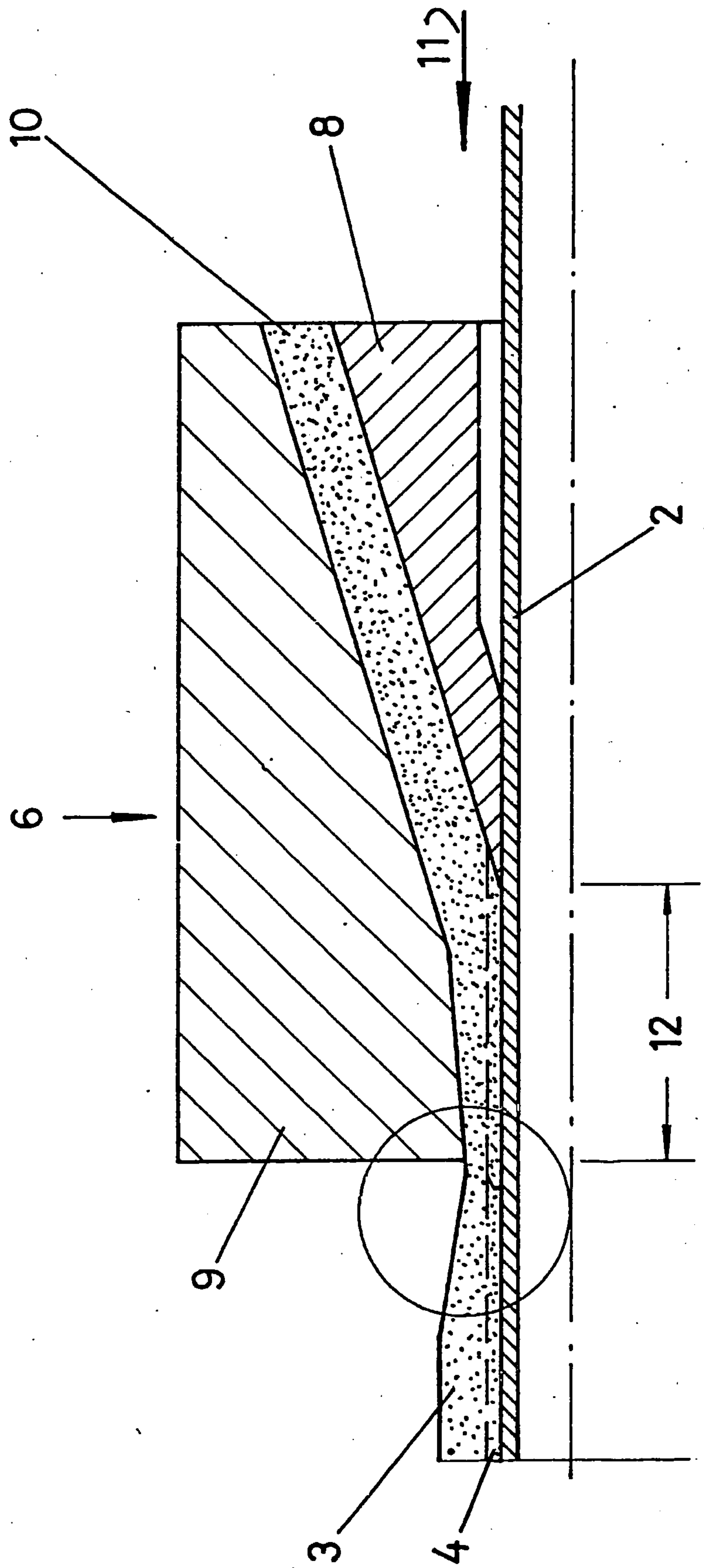

Fig.2

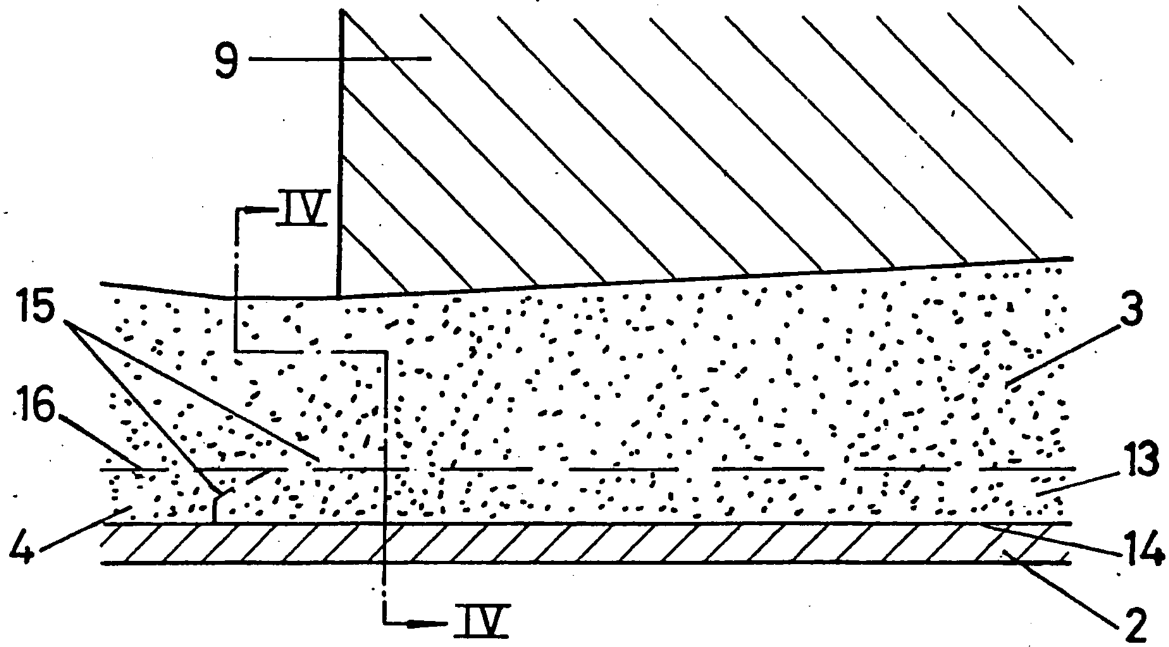

Fig.3

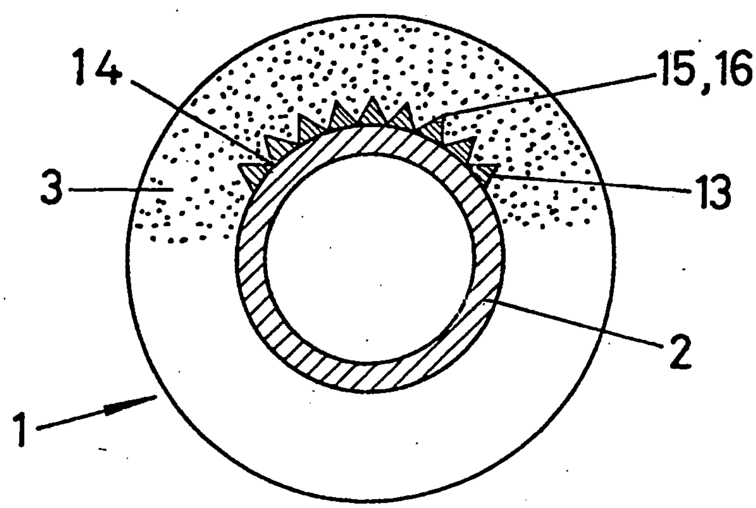

Fig.4

SPECIFICATION

Process and apparatus for the manufacture of a heat-insulated pipe

This invention relates to a process for a manufacture of a heat-insulated pipe and an apparatus therefor.

It is known from Austrian Patent Specification 298911 to manufacture a heat-insulated pipe consisting of providing a metallic core pipe and extruding around the pipe a seamless polyvinyl chloride foam jacket, the jacket being supported on the core pipe by webs which are directed toward the jacket. Polyvinyl choride (PVC) has the advantage over other foamable plastics that its heat conductivity is particularly low, even in the non-foamed state and furthermore PVC has good fire resistance even without the addition of flame retarding agents.

However, the known process for producing a seamless foam covered pipe have proved unsatisfactory because the plastics material tends to lift off the pipe so as to form an interspace between the webs and the metal pipe, thus rendering the pipe unusable.

It is an object of this invention to provide a process for the manufacture of a heat-insulated pipe in which the foregoing disadvantage is substantially mitigated.

According to one aspect of this invention there is provided a process for manufacturing a heat-insulated pipe comprising a metallic core and an extruder to seamless polyvinyl chloride foam jacket there around, the extruder jacket being supported on the core pipe by webs directed toward the jacket, said process including the steps of heating the core pipe prior to passage through an extrusion die to a temperature which is sufficiently high to provide an adequate bond between the pipe and the PVC jacket to counteract the tendency of the PVC to lift by expansion from the pipe after leaving the extrusion die but which is not so high that adhesion is lowered beyond the expansion force of the foaming jacket due to the lowering of the viscosity of the melt bond, heating plasticised polyvinyl chloride in the extruder, mixing said platicised polyvinyl chloride melt with a gas to foam said polyvinyl chloride, applying the plasticised polyvinyl chloride melt to the core pipe whilst in the extrusion die, and moving the core pipe at plasticised melt with the same velocity in the bonding zone.

As a result of the plastic melt being applied to the pipe whilst still in the extrusion die, and as a result of the control of the pipe temperature, satisfactory bonding of the plastic jacket, at the point of contact between the latter and the pipe is achieved. It should be stressed that the temperature that the pipe must not be so excessively high to cause the plastic due to loss of internal strength lifting off the metallic pipe. By maintaining the conditions required in accordance with this invention, it is possible to achieve a situation with a force of expansion which seeks to lift the plastic jacket of the metal pipe does not become greater than the adhesion with which the plastic jacket is bonded to the pipe. In a preferred embodiment the plastic composition contains solid blowing agent which releases gas on heating, the content of the solid blowing agent preferably 0.1 to 1.0% by weight, especially 0.3 to 0.7% by weight of the plastic before foaming. A composition based on azodicarbodamide is a useful blowing agent.

In an alternative embodiment, gas in the form of inert gas is forced into the plastic melt or into the extruder barrel and for such treatment a fluorochlorohydrocarbon is preferred.

So as to ensure uniform bonding of the plastic melt jacket to the metallic core pipe it is advantageous that the temperature should match the temperature of the plastic melt in the extrusion crosshead. The pipe temperature is preferably between 170 and 200°C and a temperature of between 180 and 190°C has been found to be particularly advantageous.

Particularly when the composite pipe emerges from the extrusion die at relatively high speed cooling is advisable in order to stabilise the plastic jacket which is still deformable.

According to a further aspect of this invention an apparatus for carrying out the process of the invention comprises an extrusion die, means for foaming plasticised polyvinyl chloride in said die, means for heating said core pipe prior to passage through said die to a temperature which is sufficiently high to provide an adequate bond between the pipe and the polyvinyl chloride to counteract the tendency of polyvinyl chloride to lift by expansion from the pipe after leaving the extrusion die but which is not so high that adhesion is lowered beyond the expansion force of the foaming jacket due to a lowering of the viscosity at the melt bond, and means for moving the core pipe and the plasticised melt through the bonding zone with the same velocities. Preferably, the apparatus includes a hollow mandrel which terminates in the extrusion die and needles starting from the hollow mandrel which extend at least over the bonding zone. Advantageously, the length of the bonding zone is at least 5 mm.

The invention will now be described by way of example with reference to the accompanying drawings in which:-

Figure 1 shows a cross-section through a heat-insulated pipe, on an enlarged scale,
Figure 2 shows a longitudinal section through an extrusion die,
Figure 3 shows the area encircled in Figure 2, on a larger scale, and
Figure 4 shows a cross-section along line IV-IV of Figure 3.

In Figure 1, a composite pipe 1 consists of a metallic, e.g. copper, core pipe 2 and a foam jacket 3 of plasticised polyvinyl chloride (PVC), which rests on the core pipe 2 by webs 4 which converge to an edge. The edge lines 14 of the webs 4 are bonded to the metal pipe 2. Cavities 5, which serve for further insulation, are formed between the webs 4.

Figure 2 shows an extrusion die 6 constructed as a compression die. It is connected to the end of an extrusion cross-head, which is itself not shown, but is located, in Figure 2, on the right, next to the extrusion die 6. The extruder and its screw, also not shown, are located in the usual manner upstream of the extrusion crosshead. An annular gap, which is filled with the plastic melt 10 consisting of plasticised PVC, is located between the internal diameter of the outer die 9 and the external diameter of the hollow mandrel 8. The plastic melt 10 is supplied under high pressure from the extrusion crosshead and a gas foaming agent admixed. Because of the decomposition of the added blowing agent, the plastic melt 10 contains a finely dispersed gas.

The preheated core pipe 2 is pushed through the hollow mandrel 8 in the direction of advance, indicated by arrow-headed line 11. The hollow mandrel 8 terminates within the extrusion die 6, so that the core pipe 2 and the plastic melt 10 encounter one in a bonding zone 12. The hollow mandrel 8 has a circular cross-section so that the plastic jacket deposits seamlessly round the core pipe 2.

To form the triangular cavities 5 of the foam jacket 2, the hollow mandrel 8, is provided with needles 13 (see Figure 4) which are fixed to the mandrel and merge into it. The needles 13 substantially correspond, in cross-section, to the cavities 5.

The section shown in Figure 3 is so located that it extends completely through a web 4, down to its edge lines 14. The edge of the needles 13 is shown by broken line 15 in Figure 3. The outer limiting edges of the cavities 5 is shown by line 16.

The core pipe 2 thus leaves the extrusion die 6 with a coating of plastic melt 10. After leaving the extrusion die, the gas finely dispersed in the plastic in the plastic expands virtually to atmospheric pressure, as a result of which the foam jacket 3, consisting of plasticised PVC, is formed. At low exit speeds, the foam jacket 3 can cool in air by convenction until its shape is stable. At higher speeds, special cooking measures are needed.

A copper pipe of size 15 x 1 mm was provided with a plasticised PVC foam jacket 3, using the apparatus described by using a mixture of plasticised PVC granules (Shore hardness 90) and 0.5% of solid blowing agent based on azodicarboxamide was extruded with the following temperature programme:

Extruder		Extrusion die
Zone 1	130°C	160°C
Zone 2	190°C	
Zone 3	190°C	
Zone 4	180°C	

The solid blowing agent decomposes at about 140°C and forms a gas which is finely dispersed, under pressure, in the PVC melt 10.

The copper pipe 2, heated to 180°C, was fed to the plastic melt 10. In the bonding zone 12, the pipe 2 and plastic melt 10 had the same velocity. The foam jacket 3 of the finished composite pipe 1 had a thickness of 4.5 mm and a density of 0.65 g/cm^3.

A technically entirely satisfactory composite pipe was obtained, the foam jacket 3 being firmly bonded to the metallic core pipe 2.

The extruder employed as a S45A screw extruder manufactured by Messrs. A. Reifenhauser Troisdorf and the zones 1 - 4 referred to in the above table are defined by corresponding heater windings and crosshead respectively.

CLAIMS

1. A process for manufacturing a heat-insulated pipe comprising a metallic core pipe and an extruded seamless polyvinyl chloride foam jacket around, the extruder jacket being supported on the core pipe by webs directed toward the jacket, said process including the steps of heating the core pipe prior to passage through an extrusion die to a temperature which is sufficiently high to provide an adequat bond between the pipe and the polyvinyl chloride jacket to couteract the tendency of the polyvinyl chloride to lift by expansion from the pipe after leaving the extrusion die but which is not so high that adhesion is lowered beyond the expansion force of the foaming jacket due to a lowering of the viscosity at the melt bond, heating plasticised polyvinyl chloride in the extruder, mixing said plasticised polyvinyl chloride melt with a gas to foam said polyvinyl chloride, applying the plasticised polyvinyl chloride melt to the core pipe whils whilst in the extrusion die, and moving the core pipe and plasticised melt with the same velocity in the bonding zone.
2. A process according to claim 1, wherein the plastic composition contains a solid blowing agent which releases gas when hot.
3. A process according to claim 2, wherein the content of the solid blowing agent is 0.1 to 10% by weight of the plastic before foaming.
4. A process according to claim 3, wherein the content of the solid blowing agent is 0.3 to 0.7%.
5. A process according to claims 2 to 4, wherein the solid blowing agent essentially consists of azodicarboxamide.
6. A process according to any preceding claim, wherein gas in the form of inert gas is forced into the plastic melt or into the extruder barrel.

7. A process according to claim 6, wherein a fluorochlorohydrocarbon is used as the inert gas.

8. A process according to any preceding claim, wherein the pipe temperature matches the temperature of the plastic melt in the extrusion crosshead.

9. A process according to claim 8, wherein the pipe temperature is between 170 and 200°C.

10. A process according to claim 9, wherein the pipe temperature is between 180 and 190°C.

11. A process according to any preceding claim characterised in that the composite pipe is cooled after leaving the extrusion die.

12. Apparatus for carrying out the process according to claims 1 to 11 comprising an extrusion die, means for foaming plasticised polyvinyl chloride in said die, means for heating said core pipe prior to passage through said die to a temperature which is sufficiently high to provide an adequate bond between the pipe and the polyvinyl chloride to counteract the tendency of polyvinyl chloride to lift by expansion from the pipe after leaving the extrusion die but which is not so high that adhesion is lowered beyond the expansion force of the foaming jacket due to a lowering of the viscosity at the melt bond, and means for moving the core pipe and the plasticised melt through the bonding zone with the same velocities. Preferably, the apparatus includes a hollow mandrel which terminates in the extrusion die and needles starting from the hollow mandrel which extend at least over the bonding zone. Advantageously, the length of the bonding zone is at least 5mm.

13. Apparatus, according to claim 12 wherein a hollow mandrel terminates in the extrusion die, and needles starting from the hollow mandrel extend at least over the bonding zone.

14. Apparatus according to claim 12, wherein the length of the bonding zone is at least 5 mm.

15. A process substantially as herein described with reference to and as illustrated in the accompanying drawings.

16. An apparatus substantially as herein described with reference to and as shown in the accompanying drawings.

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